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Naotake YAMAMOTO	:	**Confirmation No. 9102**
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SUBMISSION OF VERIFIED ENGLISH TRANSLATION OF FOREIGN PRIORITY DOCUMENT

Commissioner for Patents
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Sir:

Enclosed herewith is verified English translation of the foreign priority document (JP Application No. 2004-255289) for the present application, thereby perfecting the priority date of September 2, 2004.

Respectfully submitted,

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Certificate of Accuracy of Translation

The undersigned,

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certifies:

(1) I am fully conversant with both the English and the Japanese languages;

(2) I have translated into English:

Japanese Patent Application SN 2004 - 255289

(3) The translation is, to the best of my knowledge and belief, an accurate translation from the original into the English language.

Date: 5 / Aug. / 2009
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Signature:

K. Hirano

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[ENCLOSURE]	Specification 1
[ENCLOSURE]	Drawing 1
[ENCLOSURE]	Abstract 1
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[Document Name] CLAIMS

[1] A transmitting method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the transmitting method comprising:

assuming that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2), and further that a coded rate is (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2);

transforming a k-bit information bit train to (k*m)-piece pulses in total; and

transmitting sequentially the (k*m)-piece pulses to the communication path,

wherein the (k*m)-piece pulses are composed of n-piece repetitive pulse trains, and at least two pieces of the n-piece repetitive pulse trains possess lengths different from each other,

wherein the n-piece repetitive pulse trains correspond to an n-bit encoded bit train that the k-bit information bit train has been encoded at the coded rate of (k/n),

wherein the n-piece repetitive pulse trains are composed by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit encoded bit train.

[2] A transmitting method as defined in claim 1, further comprising:

acquiring communication path information on the communication path; and then

determining a number of pulses of the n-piece repetitive pulse trains.

[3] A transmitting method as defined in any of claims 1 to 2, wherein the number of pulses of the n-piece repetitive pulse trains is transmitted as pulse train information.

[4] A transmitting method as defined in claim 1, wherein the n-bit encoded bit train is a parallel encoded bit train, and

wherein the n-piece repetitive pulse trains are generated in parallel, are

parallel-to-serial converted, and then are sequentially transmitted on the communication path.

[5] A receiving method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the receiving method comprising:

receiving a transmit signal as n-piece received pulse trains, the transmit signal being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), and subsequently the n-bit encoded bit train is transformed to the n-piece repetitive pulse trains;

outputting a number of pulses composing each of the n-piece received pulse trains, based on pulse information received beforehand;

correlating individually pulses composing the n-piece received pulse trains with a predetermined template wave shape, thereby outputting correlation values;

integrating the correlation values as many as the number of pulses, thereby outputting n-piece integrated values;

performing soft decision for the n-piece received pulse trains based on the outputted n-piece integrated values, thereby outputting the soft decision results for n bits; and

performing hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits, thereby outputting the k-bit information bit train as a decoded information signal.

[6] A transceiving method comprising: a transmitting method as defined in any of claims 1 to 4; and a receiving method as defined in claim 5.

[7] A transmitting method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the transmitting method comprising:

assuming that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2), and further that a coded rate is (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2);

transforming a k-bit information bit train to (k*m)-piece pulses in total; and

transmitting sequentially the (k*m)-piece pulses to the communication path,

wherein each pulse of the repetitive pulse is generated using a pulse predetermined according to a kind of each bit in correspondence with each bit of n-piece repetitive pulse trains, at least two of the n-piece repetitive pulse trains possessing lengths different from each other,

wherein the n-piece repetitive pulse trains correspond to an n-bit encoded bit train that the k-bit information bit train has been encoded at the coded rate of (k/n), and

wherein each repetitive pulse train of the n-piece repetitive pulse trains is composed by repeating each bit of the n-bit encoded bit train a plurality of times.

[8] A transmitting method as defined in claim 7, further comprising:

acquiring communication path information on the communication path; and then

determining a number of repetitive bits of the n-piece repetitive pulse trains.

[9] A transmitting method as defined in any of claims 7 to 8, wherein the number of the repetitive bits of the n-piece repetitive pulse trains is transmitted as pulse train information.

[10] A receiving method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the receiving method comprising:

receiving a transmit signal as n-piece received pulse trains, the transmit signal being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), the n-bit encoded bit train is

further converted to pulses, and subsequently the pulses are transformed to the n-piece repetitive pulse trains;

outputting a number of pulses composing each of the n-piece received pulse trains, based on pulse information received beforehand;

correlating individually pulses composing the n-piece received pulse trains with a predetermined template wave shape, thereby outputting correlation values;

integrating the correlation values as many as the number of pulses, thereby outputting n-piece integrated values;

performing soft decision for the n-piece received pulse trains based on the outputted n-piece integrated values, thereby outputting soft decision results for n bits; and

performing hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits, thereby outputting the k-bit information bit train as a decoded information signal.

[11] A transceiving method comprising: a transmitting method as defined in any of claims 7 to 9; and a receiving method as defined in claim 10.

[12] A transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising:

an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2); and

a pulse generator operable to generate and sequentially transmit n-pieces repetitive pulse trains to the communication path by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit encoded bit train encoded by said encoder,

wherein pulses included in the n-piece repetitive pulse trains generated by said pulse generator amount to (k*m) pieces in total, and at least two pieces of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[13] A transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising:

an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2);

a pulse generator operable to generate and sequentially transmit n-pieces repetitive pulse trains to the communication path by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit encoded bit train encoded by said encoder; and

a transmitting control unit operable to control said pulse generator,

wherein said transmitting control unit controls said pulse generator so as to determine each number of pulses in the n-piece repetitive pulse trains generated by said pulse generator in a manner such that pulses included in the n-piece repetitive pulse trains amount to (k*m) pieces in total, and further that at least two of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[14] A transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising:

an encoder operable to encode a k-bit information bit train to an n-bit parallel encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and

"n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2);

an encoder operable to encode a k-bit information train to an n-bit parallel encoded bit train at the encoded rate of (k/n);

a pulse generator operable to generate and output in parallel n-piece repetitive pulse trains by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit parallel encoded bit train encoded by said encoder;

a parallel-to-serial converter operable to convert the n-piece repetitive pulse trains outputted in parallel by said pulse generator to serial repetitive pulse trains to output the serial repetitive pulse trains to the communication path; and

a transmitting control unit operable to control said pulse generator,

wherein said transmitting control unit controls said pulse generator so as to determine each number of pulses in the n-piece repetitive pulse trains generated by said pulse generator in a manner such that pulses included in the n-piece repetitive pulse trains amount to (k*m) pieces in total, and further that at least two of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[15] A transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising:

an encoder operable to encode a k-bit information bit train to an n-bit serial encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2);

a serial-to-parallel converter operable to convert the n-bit serial encoded bit train encoded by said encoder to an n-bit parallel encoded bit train;

a pulse generator operable to generate and output in parallel n-pieces repetitive pulse trains by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit parallel encoded bit train converted by said serial-to-parallel converter;

a parallel-to-serial converter operable to convert the n-piece repetitive pulse trains outputted in parallel by said pulse generator to serial repetitive pulse trains to output the serial repetitive pulse trains to the communication path; and

a transmitting control unit operable to control said pulse generator,

wherein said transmitting control unit controls said pulse generator so as to determine each number of pulses in the n-piece repetitive pulse trains generated by said pulse generator in a manner such that pulses included in the n-piece repetitive pulse trains amount to (k*m) pieces in total, and further that at least two of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[16] A transmitting device as defined in any of claims 13 to 15, wherein said transmitting control unit acquires communication information on the communication path, and then determines a number of pulses of the n-piece repetitive pulse trains.

[17] A transmitting device as defined in claim 16, wherein said transmitting control unit transmits a number of pulses composing each of the n-piece repetitive pulse trains as pulse train information.

[18] A receiving device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the receiving device comprising:

a receiving unit operable to receive a transmit signal as n-piece received repetitive pulse trains, the transmit signal being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number

not less than 2), and subsequently the n-bit encoded bit train is transformed to the n-piece repetitive pulse trains;

a receiving control unit operable to output, based on pulse train information received beforehand, a number of pulses composing each of the n-piece received repetitive pulse trains received by said receiving unit;

a pulse wave-shape correlator operable to correlate individually pulses composing each of the n-piece received repetitive pulse trains with a predetermined template wave shape, thereby outputting correlation values;

an integrator operable to integrate as many as the number of pulses composing each of the n-piece received repetitive pulse trains outputted by said receiving control unit the correlation values outputted by said pulse wave-shape correlator, thereby outputting n-piece integrated values;

a decoder operable to perform soft decision for the n-piece received repetitive pulse trains based on the n-piece integrated values outputted by said integrator, thereby outputting soft decision results for n bits; and

a decision unit operable to perform hard decision in decoding for the n-piece received repetitive pulse trains based on the soft decision results for n bits outputted by said decoder, thereby outputting the k-bit information bit train as a decoded information signal.

[19] A transceiving device comprising: a transmitting device as defined in any of claims 12 to 17; and a receiving device as defined in claim 18.

[20] A transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising:

an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one

bit of information bits ("m" is a natural number not less than 2); and

a bit train generator operable to generate n-piece repetitive bit trains in response to the n-bit encoded bit train encoded by said encoder by repeating each bit of the n-bit encoded bit train a plurality of times, thereby outputting the n-piece repetitive bit trains;

a pulse generator operable to generate a pulse predetermined in correspondence with each bit of the n-piece repetitive bit trains outputted by said bit train generator, thereby outputting the generated pulse to the communication path; and

a transmitting control unit operable to control said bit train generator,

wherein said transmitting control unit determines the plurality of times that said bit train generator performs the repeating in a manner such that bits included in the n-piece repetitive pulse trains generated by said bit train generator amount to (k*m) pieces in total, and further that at least two pieces of the n-piece repetitive pulse trains are composed of repetitive bits of numbers different from each other.

[21] A transmitting device as defined in claim 20, wherein said transmitting control unit acquires communication information on the communication path, and then determines the plurality of times that said bit train generator performs the repeating.

[22] A transmitting device as defined in any of claims 20 to 21, wherein said transmitting control unit transmits the plurality of times that said bit train generator performs the repeating as bit train information.

[23] A receiving device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the receiving device comprising:

a receiving unit operable to receive a transmitted n-piece repetitive pulse trains as n-piece received pulse trains, the transmitted n-piece repetitive pulse trains being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1,

and "n" is a natural number not less than 2), and subsequently being transmitted as the n-piece repetitive pulse trains;

a receiving control unit operable to output, based on pulse information received beforehand, a number of pulses composing each of the n-piece received pulse trains received by said receiving unit;

a pulse wave-shape correlator operable to correlate individually pulses composing each of the n-piece received pulse trains with a predetermined template wave shape, thereby outputting correlation values;

an integrator operable to integrate as many as the number of pulses composing each of the n-piece received pulse trains outputted by said receiving control unit the correlation values outputted by said pulse wave-shape correlator, thereby outputting n-piece integrated values;

a decoder operable to perform soft decision for the n-piece received pulse trains based on the n-piece integrated values outputted by said integrator, thereby outputting soft decision results for n bits; and

a decision unit operable to perform hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits outputted by said decoder, thereby outputting the k-bit information bit train as a decoded information signal.

[24] A transceiving device comprising: a transmitting device as defined in any of claims 20 to 22; and a receiving device as defined in claim 23.

[25] A transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising:

an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one

bit of information bits ("m" is a natural number not less than 2);

a bit train generator operable to repeat each bit of the n-bit encoded bit train a plurality of times to output a first time-series bit train composed of the n-piece repetitive bit trains;

an interleaver operable to change time-series of each bit of the first time-series bit train to output a second time-series bit train;

a pulse generator operable to generate a predetermined pulse for each bit of the second time-series bit train outputted by said interleaver, thereby sequentially outputting the generated pulse to the communication path; and

a transmitting control unit operable to control said bit train generator,

wherein said transmitting control unit determines the plurality of times that said bit train generator repeats in a manner such that bits included in the n-piece repetitive bit trains generated by said bit train generator amount to (k*m) pieces in total, and further that at least two pieces of the n-piece repetitive bit trains are composed of repetitive bits of numbers from each other.

[26] A transmitting device as defined in claim 25, wherein said transmitting control unit acquires communication information on the communication path, and then determines the plurality of times that said bit train generator repeats.

[27] A transmitting device as defined in any of claims 25 to 26, wherein said transmitting control unit transmits the plurality of times as bit train information.

[28] A receiving device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the receiving device comprising:

a receiving unit operable to receive transmitted pulse trains as n-piece received pulse trains, the transmitted pulse trains being n-piece received pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less

than 2), and subsequently the n-bit encoded bit train is transmitted as the n-piece received pulse trains;

a pulse wave-shape correlator operable to correlate individually pulses composing each of the n-piece received pulse trains with a predetermined template wave shape, thereby outputting a second time-series correlation value train in correspondence with the received pulse trains;

a deinterleaver operable to deinterleave the second time-series correlation value train outputted by said pulse wave-shape correlator to output a first time-series correlation value train;

a receiving control unit operable to output, based on bit train information received beforehand, a repetitive number of the first time-series correlation value train outputted by said deinterleaver;

an integrator operable to integrate as many as the repetitive number of the first time-series correlation value train outputted by said receiving control unit values of the first time-series correlation value train, thereby outputting n-piece integrated values;

a decoder operable to perform soft decision for the n-piece received pulse trains based on the n-piece integrated values outputted by said integrator, thereby outputting soft decision results for n bits; and

a decision unit operable to perform hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits outputted by said decoder, thereby outputting the k-bit information bit train as a decoded information signal.

[29] A transceiving device comprising: a transmitting device as defined in any of claims 25 to 27; and a receiving device as defined in claim 28.

[Document Name] DESCRIPTION

[Title of the Invention] TRANSMITTING METHOD, RECEIVING METHOD, TRANSCEIVING METHOD, TRANSMITTING DEVICE, RECEIVING DEVICE AND TRANSCEIVING DEVICE

[Technical Field]

[0001]

The present invention relates to a transmitting device and a receiving device used for a UWB (Ultra Wideband) communication system, and an art related thereto.

[Background Art]

[0002]

In recent years, UWB (Ultra Wideband) communication technology attracts attention as next-generation wireless-communication technology. The UWB communication technology is a high-speed wideband communication technology of a spread spectrum type using a radio wave with a large fractional bandwidth. The UWB communication technology can be used for a high-speed indoor multi-points-connection radio communication method.

[0003]

As a method of generating a signal used for the UWB communication, there is a method of transmitting a continuous chain of impulses with a short duration, directly from an antenna. The UWB communication method using such a continuous chain of impulses is called a UWB-IR (Ultra Wideband-Impulse Radio) method. The continuous chain of impulses is hereinafter called a repetitive pulse train.

[0004]

Patent Document 1 discloses, as an example of the UWB-IR method, an art which transmits data by transmitting a series of pulses of a duration in nanoseconds without using a carrier wave. The art has a feature of transmitting a signal with a transmitting level lower than a noise level over an extremely wide frequency band;

thereby the art can reduce electric power consumption comparing to the conventional radio communication with a carrier wave. Since the ultra short pulse is used, there is an advantage that the art enables high-speed communications and is strong against multi-pass interference.

[0005]

In the UWB-IR method, information is put on a repetitive pulse train to be sent. That is, it is considered that the UWB-IR method uses a repetitive code because the UWB-IR transmits repetitively a plurality of pulses for one bit of information bit train. Non Patent Document 1 has proposed "an internal turbo code UWB-IR method" as a method incorporating an error correcting code instead of the repetitive code, the error correcting code incorporated of which is considered more powerful than the repetitive code.

[0006]

Fig. 16 is a block diagram of the conventional UWB transmitting device, and shows in detail a transmitter part of "the internal turbo code UWB-IR method" which is disclosed in Non Patent Document 1.

[0007]

As shown in Fig. 16, the conventional UWB transmitting device comprises an encoder 1, a serial-to-parallel converter 2, a pulse generator 3, a parallel-to-serial converter 4 and an antenna 5. An information bit train from an information signal source S is encoded to an n-bit serial turbo encoded bit train by the encoder 1, and is converted into an n-bit parallel encoded bit train by the serial-to-parallel converter 2. The pulse generator 3 has n-piece repetitive pulse generators 3a to 3n, inputs n-bit parallel coded bits, and outputs n-piece pulse trains in parallel. The n-piece pulse trains comprise tens of to hundreds of repetitive pulses which have been generated corresponding to each coded bit, respectively. The n-piece pulse trains are parallel-to-serial converted by the parallel-to-serial converter 4, and are directly transmitted from the antenna 5.

[0008]

In the conventional UWB transmitting device shown in Fig. 16, when Ns-piece pulses in total are transmitted repetitively per one bit of the information bit train, each of the n sets of repetitive pulse generators 3a to 3n generates (Ns/n)-piece repetitive pulses, respectively.

[0009]

Fig. 17 is a block diagram of the conventional UWB receiving device, and shows in detail a receiver part of "the internal turbo code UWB-IR method" which is disclosed in Non Patent Document 1.

[0010]

As shown in Fig. 17, the conventional UWB receiving device comprises the antenna 5, a pulse wave-shape correlator 6, a pulse train integrator 7, a decoder 8 and a decision circuit 9. As for received pulses received by the antenna 5, correlation with a template wave shape is taken in the pulse wave-shape correlator 6. In the pulse train integrator 7, the correlation values are integrated as many as the number of the repetitive pulses. After a soft decision of a code is made in the decoder 8 which decodes a turbo code using the integrated correlation value, a hard decision is made, and an information bit train is restored and outputted as a decoded information signal in the decision circuit 9.

[0011]

According to the conventional technology with the internal turbo code disclosed in Non Patent Document 1, error rate characteristics can be improved without reducing transmission speed as compared with the UWB-IR method, by controlling the coded rates (1/n) in the encoder and the number of pulses (Ns) of the UWB-IR method, depending on a state of communication path or required quality.

[0012]

In the above-mentioned conventional technology, it is considered that the equal

number of pulses as the (Ns/n)-piece of repetitive pulses are generated repetitively each bit of the n-bit encoded bit train, and further that significance of every encoded bit is equal. As a result, the significance of the encoded bits cannot be adaptively changed considering a state of the communication path, in other words, is fixed. Accordingly, adaptive handling such that more repetitive pulses are allotted to an encoded bit which is susceptible to adverse effect by noises and interference from other users, and further that less repetitive pulses are allotted to an encoded bit which is hard to be influenced by the adverse effect is difficult to be performed. Furthermore, there is restriction that the number of pulses which the pulse generator 3 generates must always be a multiple of "n" when the coded rate of the encoder 1 is (k/n).

[Patent Document 1] Toku-Hyou-Hei 10-508725

[Non Patent Document 1] Naotake Yamamoto and Tomoaki Otsuki; "Evaluation of Characteristics of Internally Turbo-Coded Ultra Wideband-Impulse Radio (ITC-UWB-IR) Method", Institute of Electronics, Information and Communication Engineers, technical report RCS2002-55, pp.25-30, May 2002

[Disclosure of Invention]

[Problem(s) to be Solved by Invention]

[0013]

In view of the above, an object of the present invention is to provide a UWB transmitting device and a UWB receiving device and an art related thereto, the transmitting and receiving devices being able to perform high-quality data transmission without reducing transmission speed, by setting up the number of pulses in the UWB-IR method without the restriction and by performing weighting on the encoded bits.

[Means for Solving Problem(s)]

[0014]

Claim 1 recites a transmitting method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication

path, the transmitting method comprising: assuming that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2), and further that a coded rate is (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2); transforming a k-bit information bit train to (k*m)-piece pulses in total; and transmitting sequentially the (k*m)-piece pulses to the communication path, wherein the (k*m)-piece pulses are composed of n-piece repetitive pulse trains, and at least two pieces of the n-piece repetitive pulse trains possess lengths different from each other, wherein the n-piece repetitive pulse trains correspond to an n-bit encoded bit train that the k-bit information bit train has been encoded at the coded rate of (k/n), wherein the n-piece repetitive pulse trains are composed by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit encoded bit train.

[0015]

According to the present method, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing transmitting technology of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0016]

Claim 2 recites a transmitting method, further comprising: acquiring communication path information on the communication path; and then determining a number of pulses of the n-piece repetitive pulse trains.

[0017]

According to the present method, it is possible to adaptively change the significance of the encoded bits considering the state of the communication path. Therefore, adaptive handling such that more repetitive pulses are allotted to encoded bits easily affected by noises and interference from other users and less repetitive pulses are allotted to encoded bits hardly affected by them is possible. As a result, reliable

transmitting technology according to the UWB-IR method can be provided.

[0018]

Claim 3 recites a transmitting method, wherein the number of pulses of the n-piece repetitive pulse trains is transmitted as pulse train information.

[0019]

According to the present method, since the number of pulses of the n-piece repetitive pulse trains is transmitted as the pulse train information, a receiving side can suitably integrate correlation values of received pulses and template pulses utilizing the pulse train information, thereby providing transmitting technology according to the UWB-IR method enabling to decode received signals with high accuracy.

[0020]

Claim 4 recites a transmitting method, wherein the n-bit encoded bit train is a parallel encoded bit train, and wherein the n-piece repetitive pulse trains are generated in parallel, are parallel-to-serial converted, and then are sequentially transmitted on the communication path.

[0021]

According to the present method, it is possible to generate the n-piece repetitive bit trains simultaneously, thereby reducing process time necessary for generating the repetitive pulse trains.

[0022]

Claim 5 recites a receiving method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the receiving method comprising: receiving a transmit signal as n-piece received pulse trains, the transmit signal being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), and subsequently the n-bit encoded bit train is transformed to the n-piece repetitive pulse

trains; outputting a number of pulses composing each of the n-piece received pulse trains, based on pulse information received beforehand; correlating individually pulses composing the n-piece received pulse trains with a predetermined template wave shape, thereby outputting correlation values; integrating the correlation values as many as the number of pulses, thereby outputting n-piece integrated values; performing soft decision for the n-piece received pulse trains based on the outputted n-piece integrated values, thereby outputting the soft decision results for n bits; and performing hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits, thereby outputting the k-bit information bit train as a decoded information signal.

[0023]

According to the present method, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing transmitting technology of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0024]

Claim 6 recites a transceiving method comprising: a transmitting method as defined in any of claims 1 to 4; and a receiving method as defined in claim 5.

[0025]

According to the present method, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing transceiving technology of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0026]

Claim 7 recites a transmitting method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the transmitting method comprising: assuming that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2), and further that

a coded rate is (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2); transforming a k-bit information bit train to (k*m)-piece pulses in total; and transmitting sequentially the (k*m)-piece pulses to the communication path, wherein each pulse of the repetitive pulse is generated using a pulse predetermined according to a kind of each bit in correspondence with each bit of n-piece repetitive pulse trains, at least two of the n-piece repetitive pulse trains possessing lengths different from each other, wherein the n-piece repetitive pulse trains correspond to an n-bit encoded bit train that the k-bit information bit train has been encoded at the coded rate of (k/n), and wherein each repetitive pulse train of the n-piece repetitive pulse trains is composed by repeating each bit of the n-bit encoded bit train a plurality of times.

[0027]

According to the present method, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing transmitting technology of the UWB-IR method that utilizes various kinds of pulse-modulating methods. Furthermore, all processes until generating the n-piece repetitive bit trains can be performed in digital processing.

[0028]

Claim 8 recites a transmitting method, further comprising: acquiring communication path information on the communication path; and then determining a number of repetitive bits of the n-piece repetitive pulse trains.

[0029]

According to the present method, the same merit as claim 2 can be obtained.

[0030]

Claim 9 recites a transmitting method, wherein the number of the repetitive bits of the n-piece repetitive pulse trains is transmitted as pulse train information.

[0031]

According to the present method, since the number of the repetitive bits of the

n-piece repetitive pulse trains is transmitted as the pulse train information, a receiving side can suitably integrate correlation values of received pulses and template pulses utilizing the pulse train information, thereby providing transmitting technology of the UWB-IR method enabling to decode received signals with high accuracy.

[0032]

Claim 10 recites a receiving method in an ultra-wideband communication system performing communications by sending repetitively pulses to a communication path, the receiving method comprising: receiving a transmit signal as n-piece received pulse trains, the transmit signal being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), the n-bit encoded bit train is further converted to pulses, and subsequently the pulses are transformed to the n-piece repetitive pulse trains; outputting a number of pulses composing each of the n-piece received pulse trains, based on pulse information received beforehand; correlating individually pulses composing the n-piece received pulse trains with a predetermined template wave shape, thereby outputting correlation values; integrating the correlation values as many as the number of pulses, thereby outputting n-piece integrated values; performing soft decision for the n-piece received pulse trains based on the outputted n-piece integrated values, thereby outputting soft decision results for n bits; and performing hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits, thereby outputting the k-bit information bit train as a decoded information signal.

[0033]

According to the present method, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing receiving technology of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0034]

Claim 12 recites a transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising: an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2); and a pulse generator operable to generate and sequentially transmit n-pieces repetitive pulse trains to the communication path by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit encoded bit train encoded by the encoder, wherein pulses included in the n-piece repetitive pulse trains generated by the pulse generator amount to (k*m) pieces in total, and at least two pieces of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[0035]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a transmitting device of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0036]

Claim 13 recites a transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising: an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a

natural number not less than 2); a pulse generator operable to generate and sequentially transmit n-pieces repetitive pulse trains to the communication path by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit encoded bit train encoded by the encoder; and a transmitting control unit operable to control the pulse generator, wherein the transmitting control unit controls the pulse generator so as to determine each number of pulses in the n-piece repetitive pulse trains generated by the pulse generator in a manner such that pulses included in the n-piece repetitive pulse trains amount to (k*m) pieces in total, and further that at least two of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[0037]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a transmitting device of the UWB-IR method that utilizes various kinds of pulse-modulating methods. Furthermore, the number of the repetitive pulses generated by the pulse generator can be controlled by the transmitting control unit, thereby providing a transmitting device that definitely shares functions thereof.

[0038]

Claim 14 recites a transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising: an encoder operable to encode a k-bit information bit train to an n-bit parallel encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2); an encoder operable to encode a k-bit information train to an n-bit parallel encoded bit train at the encoded rate of (k/n); a pulse generator operable to generate and output in parallel n-piece repetitive pulse trains

by repetitively generating a pulse predetermined according to a kind of each bit in correspondence with each bit of the n-bit parallel encoded bit train encoded by the encoder; a parallel-to-serial converter operable to convert the n-piece repetitive pulse trains outputted in parallel by the pulse generator to serial repetitive pulse trains to output the serial repetitive pulse trains to the communication path; and a transmitting control unit operable to control the pulse generator, wherein the transmitting control unit controls the pulse generator so as to determine each number of pulses in the n-piece repetitive pulse trains generated by the pulse generator in a manner such that pulses included in the n-piece repetitive pulse trains amount to (k*m) pieces in total, and further that at least two of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[0039]

According to the present arrangement, utilizing the encoder that outputs the parallel encoded bit train, the output of the encoder is inputted into the pulse generator, thereby providing a transmitting device the UWB-IR method that generates in parallel the variable-length repetitive pulse trains.

[0040]

Claim 15 recites a transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising: an encoder operable to encode a k-bit information bit train to an n-bit serial encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2); a serial-to-parallel converter operable to convert the n-bit serial encoded bit train encoded by the encoder to an n-bit parallel encoded bit train; a pulse generator operable to generate and output in parallel n-pieces repetitive pulse trains by repetitively generating a pulse predetermined according to a kind of each

bit in correspondence with each bit of the n-bit parallel encoded bit train converted by the serial-to-parallel converter; a parallel-to-serial converter operable to convert the n-piece repetitive pulse trains outputted in parallel by the pulse generator to serial repetitive pulse trains to output the serial repetitive pulse trains to the communication path; and a transmitting control unit operable to control the pulse generator, wherein the transmitting control unit controls the pulse generator so as to determine each number of pulses in the n-piece repetitive pulse trains generated by the pulse generator in a manner such that pulses included in the n-piece repetitive pulse trains amount to (k*m) pieces in total, and further that at least two of the n-piece repetitive pulse trains are composed of repetitive pulses of numbers different from each other.

[0041]

According to the present arrangement, utilizing the encoder that outputs the serial encoded bit train, the output of the encoder is converted into the parallel encoded bit train, and then it is inputted into the pulse generator, thereby providing a transmitting device the UWB-IR method that generates in parallel the variable-length repetitive pulse trains.

[0042]

Claim 16 recites a transmitting device, wherein the transmitting control unit acquires communication information on the communication path, and then determines a number of pulses of the n-piece repetitive pulse trains.

[0043]

According to the present arrangement, utilizing the communication information on the communication path acquired by the transmitting control unit, the significance of the encoded bits can be adaptively changed according to the state of the communication path. Therefore, adaptive handling such that more repetitive pulses are allotted to encoded bits easily affected by noises and interference from other users and less repetitive pulses are allotted to encoded bits hardly affected by them is possible. As a

result, a reliable transmitting device according to the UWB-IR method can be provided.

[0044]

Claim 17 recites a transmitting device, wherein the transmitting control unit transmits a number of pulses composing each of the n-piece repetitive pulse trains as pulse train information.

[0045]

According to the present method, since the number of pulses of the repetitive pulse trains is transmitted as the pulse train information, a receiving device can suitably integrate correlation values of received pulses and template pulses utilizing the pulse train information, thereby enabling to decode the received signals with high accuracy.

[0046]

Claim 18 recites a receiving device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the receiving device comprising: a receiving unit operable to receive a transmit signal as n-piece received repetitive pulse trains, the transmit signal being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), and subsequently the n-bit encoded bit train is transformed to the n-piece repetitive pulse trains; a receiving control unit operable to output, based on pulse train information received beforehand, a number of pulses composing each of the n-piece received repetitive pulse trains received by the receiving unit; a pulse wave-shape correlator operable to correlate individually pulses composing each of the n-piece received repetitive pulse trains with a predetermined template wave shape, thereby outputting correlation values; an integrator operable to integrate as many as the number of pulses composing each of the n-piece received repetitive pulse trains outputted by the receiving control unit the correlation values outputted by the pulse wave-shape correlator, thereby outputting n-piece integrated

values; a decoder operable to perform soft decision for the n-piece received repetitive pulse trains based on the n-piece integrated values outputted by the integrator, thereby outputting soft decision results for n bits; and a decision unit operable to perform hard decision in decoding for the n-piece received repetitive pulse trains based on the soft decision results for n bits outputted by the decoder, thereby outputting the k-bit information bit train as a decoded information signal.

[0047]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a receiving device of the UWB-IR method that utilizes various kinds of pulse-modulating methods. Furthermore, utilizing the pulse train information received beforehand, correlation values of received pulses and template pulses can be suitably integrated, thereby enabling to decode the received signals with high accuracy.

[0048]

Claim 19 recites a transceiving device comprising: a transmitting device as defined in any of claims 12 to 17; and a receiving device as defined in claim 18.

[0049]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a transceiving device of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0050]

Claim 20 recites a transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising: an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on

condition that m-piece pulses are transmitted per one bit of information bits ("m" is a natural number not less than 2); and a bit train generator operable to generate n-piece repetitive bit trains in response to the n-bit encoded bit train encoded by the encoder by repeating each bit of the n-bit encoded bit train a plurality of times, thereby outputting the n-piece repetitive bit trains; a pulse generator operable to generate a pulse predetermined in correspondence with each bit of the n-piece repetitive bit trains outputted by the bit train generator, thereby outputting the generated pulse to the communication path; and a transmitting control unit operable to control the bit train generator, wherein the transmitting control unit determines the plurality of times that the bit train generator performs the repeating in a manner such that bits included in the n-piece repetitive pulse trains generated by the bit train generator amount to (k*m) pieces in total, and further that at least two pieces of the n-piece repetitive pulse trains are composed of repetitive bits of numbers different from each other.

[0051]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a receiving device of the UWB-IR method that utilizes various kinds of pulse-modulating methods. Furthermore, all processes until generating the n-piece repetitive bit trains can be performed in digital processing.

[0052]

Claim 21 recites a transmitting device, wherein the transmitting control unit acquires communication information on the communication path, and then determines the plurality of times that the bit train generator performs the repeating.

[0053]

According to the present arrangement, it is possible to obtain the same merit as the transmitting device recited in claim 16.

[0054]

Claim 22 recites a transmitting device, wherein the transmitting control unit transmits the plurality of times that the bit train generator performs the repeating as bit train information.

[0055]

According to the present arrangement, since the number of bits of the n-piece repetitive bit trains is transmitted as the bit train information to a receiving device, the receiving device can suitably integrate correlation values of received pulses and template pulses utilizing the bit train information, thereby enabling to decode received signals with high accuracy.

[0056]

Claim 23 recites a receiving device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the receiving device comprising: a receiving unit operable to receive a transmitted n-piece repetitive pulse trains as n-piece received pulse trains, the transmitted n-piece repetitive pulse trains being n-piece repetitive pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), and subsequently being transmitted as the n-piece repetitive pulse trains; a receiving control unit operable to output, based on pulse information received beforehand, a number of pulses composing each of the n-piece received pulse trains received by the receiving unit; a pulse wave-shape correlator operable to correlate individually pulses composing each of the n-piece received pulse trains with a predetermined template wave shape, thereby outputting correlation values; an integrator operable to integrate as many as the number of pulses composing each of the n-piece received pulse trains outputted by the receiving control unit the correlation values outputted by the pulse wave-shape correlator, thereby outputting n-piece integrated values; a decoder operable to perform soft decision for the n-piece received pulse trains

based on the n-piece integrated values outputted by the integrator, thereby outputting soft decision results for n bits; and a decision unit operable to perform hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits outputted by the decoder, thereby outputting the k-bit information bit train as a decoded information signal.

[0057]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a receiving device of the UWB-IR method that utilizes various kinds of pulse-modulating methods. Furthermore, utilizing the bit train information received beforehand, correlation values of received pulses and template pulses can be suitably integrated, thereby enabling to decode the received signals with high accuracy.

[0058]

Claim 24 recites a transceiving device comprising: a transmitting device as defined in any of claims 20 to 22; and a receiving device as defined in claim 23.

[0059]

According to the present arrangement, it is possible to adaptively change the number of repetitive pulses to be allotted to the encoded bits, thereby providing a transceiving device of the UWB-IR method that utilizes various kinds of pulse-modulating methods.

[0060]

Claim 25 recites a transmitting device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the transmitting device comprising: an encoder operable to encode a k-bit information bit train to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), on condition that m-piece pulses are transmitted per one bit of information bits ("m" is a

natural number not less than 2); a bit train generator operable to repeat each bit of the n-bit encoded bit train a plurality of times to output a first time-series bit train composed of the n-piece repetitive bit trains; an interleaver operable to change time-series of each bit of the first time-series bit train to output a second time-series bit train; a pulse generator operable to generate a predetermined pulse for each bit of the second time-series bit train outputted by the interleaver, thereby sequentially outputting the generated pulse to the communication path; and a transmitting control unit operable to control the bit train generator, wherein the transmitting control unit determines the plurality of times that the bit train generator repeats in a manner such that bits included in the n-piece repetitive bit trains generated by the bit train generator amount to (k*m) pieces in total, and further that at least two pieces of the n-piece repetitive bit trains are composed of repetitive bits of numbers from each other.

[0061]

Claim 28 recites a receiving device usable in an ultra-wideband communication system performing communications by sending repetitively pulse trains to a communication path, the receiving device comprising: a receiving unit operable to receive transmitted pulse trains as n-piece received pulse trains, the transmitted pulse trains being n-piece received pulse trains transmitted after a k-bit information bit train is encoded to an n-bit encoded bit train at a coded rate of (k/n) ("k" is a natural number not less than 1, and "n" is a natural number not less than 2), and subsequently the n-bit encoded bit train is transmitted as the n-piece received pulse trains; a pulse wave-shape correlator operable to correlate individually pulses composing each of the n-piece received pulse trains with a predetermined template wave shape, thereby outputting a second time-series correlation value train in correspondence with the received pulse trains; a deinterleaver operable to deinterleave the second time-series correlation value train outputted by the pulse wave-shape correlator to output a first time-series correlation value train; a receiving control unit operable to output, based on bit train

information received beforehand, a repetitive number of the first time-series correlation value train outputted by the deinterleaver; an integrator operable to integrate as many as the repetitive number of the first time-series correlation value train outputted by the receiving control unit values of the first time-series correlation value train, thereby outputting n-piece integrated values; a decoder operable to perform soft decision for the n-piece received pulse trains based on the n-piece integrated values outputted by the integrator, thereby outputting soft decision results for n bits; and a decision unit operable to perform hard decision in decoding for the n-piece received pulse trains based on the soft decision results for n bits outputted by the decoder, thereby outputting the k-bit information bit train as a decoded information signal.

[0062]

According to these arrangements, the transmitting device receives pulse trains that have been pulse-modulated in correspondence with the interleaved repetitive bit trains, and the receiving device deinterleaves correlation value trains in correspondence with the template wave-shape of received pulse trains to perform decoding process, thereby providing transmitting and receiving devices of the UWB-IB method that possess high error correction ability against burst noises being mixed on the communication path, and further that utilize variable-length pulse trains.

[Effect of Invention]

[0063]

According to the present invention, the number of the repetitive pulses in the UWB-IR method is set up without restriction, and then weighting on the encoded bits is performed, thereby providing a UWB transmitting device and a UWB receiving device that can realize data transmission with high quality without reducing the transmission speed.

[Best Mode for Carrying Out the Invention]

[0064]

Embodiments of the present invention are explained with reference to the following drawings.

[0065]

(Embodiment 1)

Fig. 1 is a block diagram of a transmitting device according to Embodiment 1 of the present invention. As shown in Fig. 1, the transmitting device of the UWB-IR method of the present embodiment comprises an encoder 20, a pulse generator 30, and an antenna 90.

[0066]

Hereinafter, operation of the transmitting device of the present embodiment is explained. A k-bit information bit train inputted from an information signal source 10 is encoded to an n-bit encoded bit train with a coded rate (k/n) by the encoder 20 ("k" is a natural number not less than "1", and "n" is a natural number not less than "2"). The n-bit encoded bit train is inputted into the pulse generator 30. In the pulse generator 30, a series of tens of pulses to hundreds of pulses each having a short duration are generated repetitively per each bit of the n-bit encoded bit train, and the pulses are transmitted from the antenna 90. At this time, amplitudes of signals are smaller than the amplitudes of surrounding noises; radio waves with an extremely wide fractional bandwidth are radiated.

[0067]

When the number of pulses which is to be transmitted repetitively per one bit of the information bits is m pieces ("m" is a natural number not less than "2"), the total of the pulses transmitted to the k-bit information bit train is (k*m) pieces. The total (k*m)-piece pulses are composed of the n-piece repetitive pulse trains generated by the pulse generator 30. Furthermore, each repetitive pulse train of the n-piece repetitive pulse trains is composed by repeating a pulse generated by pulse modulation of each bit of the n-bit encoded bit train according to the kind of the bit (namely, according to the

bit being “0” or “1”).

[0068]

In the conventional UWB-IR method, the above-mentioned n-piece pulse trains are composed of pulses of equal numbers, irrespective of the kind of the encoded bit train. In the transmitting device of the present embodiment, the above-mentioned n-piece pulse trains are composed of pulses of different numbers. In other words, a pulse train which is easily affected by noises in a communication path is allotted increased number of pulses, and a pulse train which is hardly affected by the noises is allotted reduced number of pulses. Thereby, the occurrence probability of noise-caused errors can be lowered.

[0069]

Fig. 10 is an explanatory drawing for generating repetitive pulse trains according to Embodiment 1 of the present invention. In this figure, a k-bit information bit train 201 “010” (k= 3 in the example of Fig. 10) is encoded to an n-bit encoded bit train 202 “00101” (n=5, similarly) at a coded rate (k/n= 3/5, similarly).

[0070]

For the n-bit encoded bit train 202 “00101”, n-piece repetitive pulse trains 203 (n= 5, similarly) are generated. In Fig. 10, four P pulses are generated in response to the first bit “0” of the encoded bit train 202, four P pulses are generated in response to the second bit “0” of the encoded bit train 202, three Q pulses are generated in response to the third bit “1” of the encoded bit train 202, three P pulses are generated in response to the fourth bit “0” of the encoded bit train 202, and four Q pulses are generated in response to the fifth bit “1” of the encoded bit train 202. The total pulses of five repetitive pulse trains 203 are 18 pieces. In the five repetitive pulse trains 203 of Fig. 10, the P pulses and the Q pulses are described with symbols “P” and “Q.”

[0071]

The P pulses and the Q pulses are pulses which modulate a bit “1” and a bit “0”.

As long as the P pulses and the Q pulses can be distinguished from each other, any kind of modulation method may be used. In the example shown in Fig. 10, a pulse position modulation (PPM) method using a dipulse is used. Alternatively, other modulation methods such as a pulse amplitude modulation (PAM), an ON/OFF keying modulation (OOK), or a bi-phase modulation (BPSK) may be used.

[0072]

Fig. 11 is an illustration showing wave shapes in the repetitive pulse trains according to Embodiment 1 of the present invention. In an upper part of the Fig. 11, a connection part of a pulse train composed of the P pulses 204 and a pulse train composed of the Q pulses 205 is shown with a symbol 206, and in a lower part of Fig. 11, it is also shown using a modulated wave shape 207. The P pulses 204 and the Q pulses 205 are pulse position modulated pulses using the above-mentioned dipulse.

[0073]

As explained above, the transmitting device of the present embodiment can perform transmitting of information according to the UWB-IR method by encoding an information bit train from the information signal source 10 with the encoder 20, generating the modulated encoded pulse trains in the pulse generator 30, and transmitting the modulated encoded pulse trains from the antenna 90.

[0074]

(Embodiment 2)

Fig. 2 is a block diagram of a transmitting device according to Embodiment 2 of the present invention. In Fig. 2, description regarding the same components as in Fig. 1 is omitted by giving the same symbols.

[0075]

The transmitting device of the present embodiment as shown in Fig. 2 comprises the encoder 20, the pulse generator 30, and the antenna 90. Compared with the transmitting device of Embodiment 1 of the present invention as shown in Fig. 1, in

the transmitting device of the present embodiment, a transmitting control unit 40 operable to control the pulse generator 30 is additionally provided.

[0076]

The transmitting control unit 40 acquires communication path information transmitted from a receiving device, the information indicating a communication state of a communication path. The transmitting control unit 40 determines a number of pulses of the repetitive pulse train to be generated for every bit of the encoded bit train by the pulse generator 30.

[0077]

In the following, a case is explained where the communication path information transmitted from the receiving device includes error rates for a bit "1" and a bit "0" received by the receiving device. For example, when the error rate of the bit "1" is almost equal to a permissible value, the transmitting control unit 40 controls the pulse generator 30 in a manner such that the number of pulses of the repetitive pulse train corresponding to the bit "1" is increased and further that the number of pulses of the repetitive pulse train corresponding to the bit "0" is reduced.

[0078]

The transmitting control unit 40 transmits the number of pulses of the repetitive pulse trains, generated by the pulse generator 30, to the receiving device as pulse information. This pulse information may be transmitted to the receiving device by being included in preamble pulses which are placed at a head of a series of repetitive pulse trains. When the transmitting control unit 40 changes periodically the number of pulses of the repetitive pulse trains to be generated by the pulse generator 30, only the pulse information may be transmitted whenever the changes are made. The receiving device uses the pulse information when decoding the received signal. In the case of the five repetitive pulse trains 203 shown in Fig. 10, the numbers of repetitive pulses of the repetitive pulse trains 203 generated by the pulse generator 30 are "4", "4", "3", "3" and

"4", and these numeric values are transmitted to the receiving device as the pulse information.

[0079]

Thus, the transmitting device of the present embodiment can control the number of pulses of repetitive pulse trains adaptively according to the communication state of the communication path.

[0080]

(Embodiment 3)

Fig. 3 is a block diagram of a transmitting device according to Embodiment 3 of the present invention. In Fig. 3, explanation of components same as shown in Fig. 1 is omitted attaching the same symbols as in Fig. 1.

[0081]

The transmitting device of the present embodiment shown in Fig. 3 comprises the encoder 20, the pulse generator 30, the transmitting control unit 40, a parallel-to-serial converter 50, and the antenna 90. The pulse generator 30 comprises a first pulse train generator 31, a second pulse train generator 32, and an n-th pulse train generator 33.

[0082]

A k-bit information bit train is inputted from an information signal source 10. The encoder 20 encodes the k-bit information bit train to an n-bit encoded bit train in parallel format at a coded rate (k/n), and then outputs the n-bit encoded bit train to the pulse generator 30 in parallel.

[0083]

In the pulse generator 30, the first pulse train generator 31 generates a first repetitive pulse train corresponding to the first bit of the n-bit encoded bit train, the second pulse train generator 32 generates a second repetitive pulse train corresponding to the second bit of the n-bit encoded bit train, similarly the n-th pulse train generator 33

generates a n-th repetitive pulse train corresponding to the n-th bit of the n-bit encoded bit train, and outputs in parallel these n-piece pulse trains. These pulses generated by the pulse train generators 31 to 33 are composed of the P pulses 204 and the Q pulses 205 based on pulse position modulation using the dipulse, according to Fig. 10 of the explanatory drawing of the repetitive pulse train generation in Embodiment 1 of the present invention.

[0084]

Numbers of pulses generated by the pulse train generators 31 to 33 of the pulse generator 30 are controlled by the transmitting control unit 40. In other words, the transmitting control unit 40 acquires the communication path information indicating the state of the communication path transmitted from the receiving device, and determines the numbers of pulses generated by the pulse train generators 31 to 22 of the pulse generator 30.

[0085]

The parallel-to-serial converter 50 converts the n-piece repetitive pulse trains, which the pulse generator 30 generates and outputs in parallel, into repetitive pulse trains in serial format, and then transmits sequentially the repetitive pulse trains from the antenna 90.

[0086]

In addition, the transmitting control unit 40 transmits the numbers of pulses of the repetitive pulse trains, which the pulse train generators 31 to 33 generate, to the receiving device as pulse information. This pulse information may be transmitted to the receiving device by being included in preamble pulses which are placed at a head of a series of repetitive pulse trains. When the transmitting control unit 40 changes periodically the numbers of pulses of the repetitive pulse trains to be generated by the pulse generator 30, only the pulse information may be transmitted whenever the changes are made. The receiving device uses the pulse information when decoding the

received signals.

[0087]

Thus, the transmitting device of the present embodiment can adaptively control the number of pulses of the repetitive pulse trains according to the communication state of the communication path, thereby transmitting information using the UWB-IR method.

[0088]

(Embodiment 4)

Fig. 4 is a block diagram of a transmitting device according to Embodiment 4 of the present invention. In Fig. 4, explanation of components same as shown in Fig. 3 is omitted attaching the same symbols as in Fig. 3.

[0089]

The transmitting device of the present embodiment shown in Fig. 4 comprises the encoder 20, a serial-to-parallel converter 60, the pulse generator 30, the transmitting control unit 40, the parallel-to-serial converter 50, and the antenna 90. The encoder 20 encodes a k-bit information bit train inputted from the information signal source 10 to an n-bit serial encoded bit train at a coded rate (k/n).

[0090]

The serial-to-parallel converter 60 converts the n-bit serial encoded bit train outputted by the encoder 20 into the n-bit parallel encoded bit train, and outputs the n-bit parallel encoded bit train to the pulse generator 30 in parallel.

[0091]

The other operation of the transmitting device of the present embodiment is the same as that of Embodiment 3 of the present invention, explanation of which is omitted accordingly.

[0092]

Thus, by using the encoder 20 that outputs the serial encoded bit train, the

transmitting device of the present embodiment can transmit information of the UWB-IR method while adaptively controlling the number of pulses of the repetitive pulse trains according to the communication state of the communication path.

[0093]

(Embodiment 5)

Fig. 5 is a block diagram of a receiving device according to Embodiment 5 of the present invention. The receiving device of the present embodiment comprises an antenna 100, a receiving unit 110, a pulse wave-shape correlator 120, an integrator 130, a receiving control unit 140, a decoder 150, and a decision unit 160.

[0094]

Referring to Fig. 6, operation of the receiving device of the present embodiment is explained.

[0095]

The receiving unit 110 receives as n-piece received pulse trains, via the antenna 100, n-piece pulse trains of the UWB-IP method that have been transmitted by either one of the transmitting devices mentioned in Embodiments 1 to 4 of the present invention.

[0096]

The pulse wave-shape correlator 120 correlates each pulse of the n-piece received pulse trains, which the receiving unit 110 has received, with a template wave shape that has been set up beforehand. The operation is explained referring to Fig. 12.

[0097]

Fig. 12(a) is an illustration showing a template wave shape according to Embodiment 5 of the present invention. Fig. 12(b) is an illustration showing a received p-pulse wave shape according to Embodiment 5 of the present invention. Fig. 12(c) is an illustration showing a received q-pulse wave shape according to Embodiment 5 of the present invention.

[0098]

The received p pulse p(t) of Fig. 12(b) and the received q-pulse q(t) of Fig. 12(c) are received pulses that compose the n-piece received pulse trains, which the receiving unit 110 has received. The received p-pulse p(t) is a pulse that the receiving unit 110 has received the P pulse 204 corresponding to the encoded bit "0", and the received q-pulse q(t) is a pulse that the receiving unit 110 has received the Q pulse 205 corresponding to the encoded bit "1".

[0099]

The template wave shape R(t) of Fig. 12(a) is a wave shape for reference that is created based on an ideal received p-pulse p0(t) and an ideal received q-pulse q0(t), ideal received pulses of which are assumed to be received in a state where no noise is mixed on the communication path. The template wave shape R(t) is defined by Formula 1.

[0100]

(Formula 1)

$$R(t) = p0(t) - q0(t)$$

[0101]

The pulse wave-shape correlator 120 of Fig. 5 calculates a correlation value mp for each received pulse V (t) of the n-piece received pulse trains and the template wave shape R (t) using in the following formula, the n-piece received pulse trains having been received by the receiving unit 110.

[0102]

(Formula 2)

$$mp = \int_{t0}^{t1} R(t)\, V(t)\, dt$$

[0103]

Herein, the lower limit t0 and the upper limit t1 of the integral interval define a time interval, generally called as a frame length, where one piece of the received pulse V(t) of the received pulse train exists in.

[0104]

As it can be easily presumed from the location relationship on the time axis between the template wave shape R (t) shown in Fig. 12 and the received p-pulse wave shape p (t) or the received q-pulse wave shape q(t), when the received pulse V(t) is the received p-pulse p(t), the correlation value mp calculated by Formula 2 possesses a plus value, or when the received pulse V(t) is the received q-pulse q(t), the correlation value mp calculated by Formula 2 possesses a minus value.

[0105]

Referring to Fig. 6 again, based on the bit train information sent beforehand from the transmitting device, the receiving control unit 140 determines the number of pulses of the n-piece received pulse trains which the receiving unit 110 has received, and outputs the number of pulses to the integrator 130.

[0106]

The integrator 130 integrates the correlation values of each pulse of the n-piece received pulse trains as many as the number of pulses of the n-bit received pulse trains and outputs n-piece integrated values. Herein, the correlation values have been calculated by the pulse wave-shape correlator 120 according to Formula 2, and the number of pulses has been outputted by the receiving control unit 140. As a result caused by the integration, even when the received pulse V(t) includes a lot of noises, the received pulse V(t) can be identified more clearly whether it is the received p-pulse or the received q-pulse.

[0107]

The decoder 150 performs soft decision for the n-piece received pulse trains based on the n-piece integrated values outputted by the integrator 130, and outputs an

n-bit soft decision result.

[0108]

The decision unit 160 performs hard decision for the n-piece received pulse trains, which is the final decoding processing, based on the n-bit soft decision result outputted by the decoder 150, and outputs a k-bit information bit train as a decoded information signal.

[0109]

Fig. 13 is an explanatory drawing of signal processing in the receiving device according to Embodiment 5 of the present invention. The figure shows a state where the receiving device of the present embodiment shown in Fig. 5 receives, via the communication path, the five pieces of the repetitive pulse trains 203 shown in Fig. 10 as the received pulse trains 210. (the symbol of "p" shows the received p-pulse 215, and the symbol of "q" shows the received q-pulse 215.) The receiving control unit 140 has received the pulse train information beforehand, and notifies the integrator 130 that the received pulse trains are composed of five pieces of pulse trains, each pulse train having the number of pulses; "4", "4", "3", "3", and "4."

[0110]

The pulse wave-shape correlator 120 calculates a correlation value mp 211 of each received pulse of the five pieces of received pulse trains 210 and the template wave shape according to Formula 2. Since the calculation result of the correlation value mp 211 is not necessarily an integer, the calculated results are shown by only signs of "+" or "-" of the value in Fig. 13.

[0111]

The integrator 130 integrates the correlation value mp 211 as many as the number of the repetitive pulses of each pulse train, using the pulse information notified by the receiving control unit 140, and then the integrator 130 outputs five pieces of integrated values 212. As illustrated in Fig. 13, the integrated value 212 is not

necessarily an integer.

[0112]

The decoder 150 performs soft decision for the five pieces of integrated values 212, and outputs a soft decision result of 5 bits. (The soft decision result is not necessarily an integer, either.) The decision unit 160 obtains a hard decision result 213 "00101" before decoding, based on the soft decision result of 5 bits. Then the decision unit 160 decodes the hard decision result to acquire an information bit train 214 "010". The hard decision result 213 "00101" before decoding is not necessarily explicitly outputted as one processing result, it is described explicitly just for explanation.

[0113]

Thus, the receiving device of the present embodiment can receives n-piece pulse trains as n-piece received pulse trains and decode the n-piece received pulse trains to obtain a k-bit information bit train. The n-piece pulse trains are generated by encoding a k-bit information using the transmitting device in any of Embodiments 1 to 4 of the present invention, and then are transmitted by the transmitting device according to the UWB-IR method.

[0114]

(Embodiment 6)

Fig. 6 is a block diagram of a transmitting device according to Embodiment 6 of the present invention. In Fig. 6, explanation of components same as shown in Fig. 1 is omitted attaching the same symbols as in Fig. 1.

[0115]

The transmitting device of the present embodiment shown in Fig. 6 comprises the encoder 20, the bit train generator 70, the transmitting control unit 40, the pulse generator 30, and the antenna 90. Hereafter, operation of the transmitting device of the present embodiment is explained.

[0116]

A k-bit information bit train inputted from an information signal source 10 is encoded to an n-bit encoded bit train by the encoder 20 at an encoded rate (k/n). The n-bit encoded bit train is inputted into the bit train generator 70.

[0117]

The bit train generator 70 generates n-piece repetitive bit trains, wherein the same bit is repeated for plural times for each bit of the n-bit encoded bit train that has been inputted.

[0118]

At this time, the transmitting control unit 40 obtains the communication path information sent from a receiving device, and based on the communication path information, the transmitting control unit 40 determines each bit number of the n-piece repetitive bit trains to be generated by the bit train generator 70. However, the total number of bits is maintained to be constant.

[0119]

The pulse generator 30 generates, in response to each bit of the n-piece repetitive bit trains generated by the bit train generator 70, depending on the kind of the bit (that is, depending on a case that the bit is either "0" or "1") predetermined pulses. Thereafter, the pulse generator 30 transmits the predetermined pulses from the antenna 90 one after another.

[0120]

Fig. 14 is an explanatory drawing for generating repetitive bit trains according to Embodiment 6 of the present. In the explanatory drawing similar to the transmitting device of Embodiment 1 of the present invention shown in Fig. 10, the transmitting device of the present embodiment uses a P pulse 204 corresponding to a bit "0" and a Q pulse 205 corresponding to a bit "1" as the modulated pulse. The P pulse 204 and the Q pulse 205 illustrate pulse position modulation pulses using dipulses.

[0121]

In Fig. 14, an information bit train 201 "010" of k-bit (k=3 in the present example) is encoded to an encoded bit train 202 "00101" of n-bit (n=5, similarly). Five pieces of repetitive bit trains 217 are generated for the five-bit encoded bit train 202, where the same bit is repeated for plural times in each piece of the repetitive bit trains. In other words, a repetitive bit train "0000" is generated for the first bit "0" of the encoded bit train 202. A repetitive bit train "0000" is generated for the second bit "0" of the encoded bit train 202. A repetitive bit train "111" is generated for the third bit "1" of the encoded bit train 202. A repetitive bit train "000" is generated for the fourth bit "0" of the encoded bit train 202. Furthermore, a repetitive bit train "1111" is generated for the fifth bit "1" of the encoded bit train 202.

[0122]

The bit number of repeating the same bit, that is the number of repetitive bits of each repetitive bit train, is controlled by the transmitting control unit 40. In other words, the transmitting control unit 40 obtains the communication path information indicating a state of the communication path from a receiving device, and based on the communication path information determines the bit number of the five pieces of repetitive bit trains 217 to be generated by the bit train generator 70, under the condition that the total number of bits is constant.

[0123]

The pulse generator 30 converts each bit of the five pieces of repetitive bit trains 217, which have been generated in the above-mentioned manner, to a modulated pulse. In other words, the pulse generator 30 converts the bit "0" to the P pulse 204 and the bit "1" to the Q pulse 205; thereby, generating five pieces of repetitive pulse trains 203. The pulse generator 30 then transmits the five pieces of repetitive pulse trains 203 from the antenna 90 one after another.

[0124]

In addition, the transmitting control unit 40 transmits each bit number of

repetitive bits of the repetitive bit trains 217, which the bit train generator 70 generates, to the receiving device. In the example of Fig. 14, the bit train information is composed of the number of repetitive bit "4", "4", "3", "3", and "4" of the five pieces of repetitive bit trains.

[0125]

The bit train information may be transmitted to the receiving device by being included in preamble pulses which are placed at the head of a series of repetitive bit trains. When the transmitting control unit 40 changes periodically the respective bit number of the repetitive bit trains to be generated by the bit train generator 70, only the bit train information may be separately transmitted whenever the changes are made. The receiving device uses the bit information when decoding received signals.

[0126]

Signals of the UWB-IR method transmitted by the transmitting device according to the present Embodiment can be decoded under the condition that the receiving device described in Embodiment 5 regards the bit information as the pulse information. To be more specific, in the receiving device shown in Fig. 5, the receiving control unit 140, based on the bit information received from the transmitting device of the present Embodiment, calculates a repetitive pulse number of the n-piece received pulse trains received by the receiving unit 110, and outputs a calculated result to the integrator 130 instructing a number that the integrator 30 should integrate the correlation value mp. The following operation is the same as the operation of the receiving device described in Embodiment 5 of the present invention, and explanation thereof is omitted accordingly.

[0127]

As mentioned above, according to the transmitting device of the present embodiment, it is possible to adaptively change the number of pulses of the repetitive pulse trains according to the communication state of the communication path, thereby

realizing the transmitting device using the UWB-IR method that utilizes a various kinds of pulse-modulating methods. In addition, all process until generating the n-piece repetitive bit trains can be realized in digital processing.

[0128]

(Embodiment 7)

Fig. 7 is a block diagram of a transmitting device according to Embodiment 7 of the present invention. In Fig. 7, explanation of components same as shown in Fig. 6 is omitted attaching the same symbols as in Fig. 6.

[0129]

As shown in Fig. 7, the transmitting device according to the present Embodiment comprises the encoder 20, the bit train generator 70, the transmitting control unit 40, an interleaver 80, the pulse generator 30, and the antenna. In the transmitting device of the present embodiment, the interleaver 80 is newly added between the bit train generator 70 and the pulse generator 30, compared with the transmitting device of Embodiment 6 of the present invention shown in Fig. 6. Accordingly, the operation of the transmitting device of the present embodiment is the same as that of the transmitting device of Embodiment 6 of the present invention except for operation related to the interleaver 80.

[0130]

In the transmitting device of the present embodiment, the interleaver 80 changes the time-based locations of bits (hereinafter, called the "first time-series") of the n-piece repetitive bit trains generated by the bit train generator 70 to generate a bit train of new time-based locations of bits (hereinafter, called the "second time-series"). The pulse generator 30 converts each bit of the second time-series bit train created by the interleaver 80 into pulses, and transmits the pulses from the antenna 90. Therefore, the second time-series pulse train is transmitted from the antenna 90.

[0131]

Fig. 8 is a block diagram of s receiving device according to Embodiment 7 of the present invention. In Fig. 8, explanation of components same as shown in Fig. 8 is omitted attaching the same symbols as in Fig. 5.

[0132]

The receiving device according to the present embodiment comprises an antenna 100, the receiving unit 110, the pulse wave-shape correlator 120, a deinterleaver 170, the integrator 130, the receiving control unit 140, the decoder 150, and the decision unit 190. In the receiving device of the present embodiment, the deinterleaver 170 is newly added between the pulse wave-shape correlator 120 and the integrator 130, compared with the receiving device of Embodiment 5 of the present invention shown in Fig. 5. Therefore, the operation of the receiving device of the present embodiment in steps posterior to the deinterleaver 170 is the same as that of the receiving device of Embodiment 5 of the present invention.

[0133]

The operation of the receiving device of the present embodiment is explained referring to Fig. 8.

[0134]

The receiving unit 110 receives using the antenna 100, as the received pulse train, the second time-series pulse train transmitted by the transmitting device according to the present embodiment shown in Fig. 7.

[0135]

The pulse wave-shape correlator 120 correlates each pulse of the received pulse train received by the receiving unit 110 with the template wave shape, and outputs the correlation value. A series of correlation values outputted by the pulse wave-shape correlator 120 constitutes a second time-series correlation value train.

[0136]

The deinterleaver 170 deinterleaves and converts the second time-series

correlation value train into first time-series repetitive correlation value trains.

[0137]

The receiving control unit 140 determines the number of repetitive bits of the n-piece bit trains corresponding to the first time-series correlation value trains, based on the bit train information transmitted beforehand from the transmitting device, and outputs the number of repetitive bits to the integrator 130.

[0138]

The integrator 130 integrates the first time-series repetitive correlation value trains as many as the number of repetitive bits of the n-piece bit trains outputted by the receiving control unit 140, and outputs n-piece integrated values.

[0139]

The decoder 150 performs soft decision based on the n-piece integrated values, and outputs a soft decision result for n-bit.

[0140]

The decision unit 160 performs hard decision that is the final decoding for the received pulse train based on the soft decision result of n-bit outputted by the decoder 150, and outputs the k-bit information bit train as the decoding information signal.

[0141]

Next, operation of the interleaver 80 of the transmitting device and the deinterleaver 170 of the receiving device of the present embodiment is briefly explained referring to Fig. 15.

[0142]

Now, it is assumed that the first time-series repetitive bit train generated by the bit train generator 70 of Fig. 8 is a repetitive bit train 221 “n1, n2, n3, n4, n5, n6, n7, n8, n9, and n10”, as shown in Fig. 15.

[0143]

The interleaver 80 changes the time-series of the first time-series repetitive bit

train 221 and outputs an interleaver output 222 "n1, n6, n2, n7, n3, n8, n4, n9, n5, and n10" of the second time-series bit train, according to a predetermined conversion rule. In the present example, the first time-series repetitive bit train 221 is divided into a first part and a second part of two parts, and bits are taken out in head-to-tail order, from the first part and the second part to create the interleaver output 222 of the second time-series bit train.

[0144]

Each bit in the interleaver output 222 is converted into either the P pulse 204 or the Q pulse 205 by the pulse generator 30 to be transmitted. Therefore, the pulse train transmitted from the transmitting device is the second time-series train.

[0145]

In the receiving device, the receiving unit 110 receives the second time-series pulse train of the received pulse train. The pulse wave-shape correlator 120 correlates each pulse of the received pulse train with the template wave shape, and outputs a correlation value train 223 "mp1, mp6, mp2, mp7, mp3, and "mp8, mp4, mp9, mp5, and mp10" as shown in Fig. 15. The correlation value train 223 is the second time-series train.

[0146]

The deinterleaver 170 conversely follows the conversion rule which the interleaver 80 has used, converts the time-series of the second time-series correlation value train 223 into the deinterleaver output 224 "mp1, mp2, mp3, and "mp4, mp5, mp6, mp7, mp8, mp9, and mp10", and outputs the output 224 of the first time-series correlation value train.

[0147]

Thus, in the transmitting device of the present embodiment, the first time-series bit train is interleaved to the second time-series bit train, and the second time-series pulse train is transmitted. In the receiving device of the present embodiment, the second

time-series correlation value train is deinterleaved and returned to the first time-series correlation value train.

[0148]

Attaching the interleaver 80 to the transmitting device enables to simultaneously produce both of the time diversity effectiveness and the burst error suppression effectiveness over each coded bit, and hence, the error rate characteristics of the signal received by the receiving device can be improved further. Therefore, the transmitting device and the receiving device of the present embodiment are especially effective in environment where burst-type noises often occur.

[0149]

(Embodiment 8)

Fig. 9 is a block diagram of a transceiving device according to Embodiment 8 of the present invention. In Fig. 9, explanation of components same as shown in Fig. 2 or Fig. 5 is omitted attaching the same symbols as in Figs. 2 or 5.

[0150]

The transceiving device of the present embodiment comprises the encoder 20, the pulse generator 30, the receiving unit 110, the pulse wave-shape correlator 120, the integrator 130, the decoder 150, the decision unit 160, a transceiving control unit 303, an antenna switching unit 304, and the antenna 90.

[0151]

The transceiving device of the present embodiment is provided by unifying the transmitting device in Embodiment 2 of the present invention shown in Fig. 2 and the receiving device in Embodiment 5 of the present invention shown in Fig. 5.

[0152]

The operation of the transceiving device of the present embodiment in a transmitting mode is basically same as the operation of the transmitting device in Embodiment 2 of the present invention shown in Fig. 2. Accordingly, only outline

thereof is explained in the following.

[0153]

An information bit train, which has been inputted from an input terminal 301 as transmitting data, is encoded into an encoded bit train by the encoder 20. The encoded bit train is converted into repetitive pulse trains by the pulse generator 30, and then transmitted to a partner's transceiver via the antenna 90 after passing through the antenna switching unit 304. Moreover, each number of pulses of the repetitive pulse trains generated by the pulse generator 30 is controlled by the transceiving control unit 303 based on the communication path information. The contents of the control are transmitted to the partner's transceiver as pulse information.

[0154]

The operation of the transceiving device of the present embodiment in a receiving mode is basically same as the operation of the receiving device in Embodiment 5 of the present invention shown in Fig. 5. Accordingly, only outline thereof is explained in the following.

[0155]

The received pulse trains received by the antenna 90 pass through the antenna switching unit 304, and receiving process by the receiving unit 110 is performed thereon. The pulse wave-shape correlator 120 correlates each pulse of the received pulse trains with the template wave shape. The integrator 130 integrates the acquired correlation value. The decoder 150 performs soft decision for the correlation value, the decision unit 160 performs hard decision for the soft decision result, and outputs the decoded information bit train to an output terminal 302 as received data. The interval over which the integrator 130 integrates the correlation value (that is, the number of pulses) is controlled by the transceiving control unit 303 based on the pulse information that has been sent from a partner's transmitter beforehand.

[0156]

As roughly explained above, according to the present embodiment, it is possible to provide the transceiving device using the UWB-IR method that utilizes a various kinds of pulse-modulating methods, and further that adaptively change the number of the repetitive pulses to be generated for the encoded bit.

[0157]

As explained above, the subject-matter of the present embodiment exists in realizing the transmitting device and the receiving device that can communicate information according to the UWB-IR method while adaptively controlling the number of pulses of the repetitive pulse trains in correspondence with the state of the communication path, therefore, as long as not exceeding the subject-matter of the present invention, various applications, modifications, or the like can be made.

[Industrial Applicability]

[0158]

The transmitting device and the receiving device according to the present invention can be used, for example, in a field of high-speed indoor multi-points-connection radio communication for performing communication using the UWB-IR method, and also in applied fields thereof.

[Brief Description of Drawings]

[0159]

[Fig. 1] block diagram of a transmitting device according to Embodiment 1 of the present invention;

[Fig. 2] block diagram of a transmitting device according to Embodiment 2 of the present invention;

[Fig. 3] block diagram of a transmitting device according to Embodiment 3 of the present invention;

[Fig. 4] block diagram of a transmitting device according to Embodiment 4 of the present invention;

[Fig. 5] block diagram of a transmitting device according to Embodiment 5 of the present invention;

[Fig. 6] block diagram of a receiving device according to Embodiment 6 of the present invention;

[Fig. 7] block diagram of a receiving device according to Embodiment 7 of the present invention;

[Fig. 8] block diagram of a transmitting device according to Embodiment 7 of the present invention;

[Fig. 9] block diagram of a transceiving device according to Embodiment 8 of the present invention;

[Fig. 10] explanatory drawing for generating repetitive pulse trains according to Embodiment 1 of the present invention;

[Fig. 11] illustration showing wave shapes in the repetitive pulse trains according to Embodiment 1 of the present invention;

[Fig. 12] (a) illustration showing a template wave shape according to Embodiment 5 of the present invention, (b) illustration showing a received p-pulse wave shape according to Embodiment 5 of the present invention, and (c) illustration showing a received q-pulse wave shape according to Embodiment 5 of the present invention;

[Fig. 13] explanatory drawing of signal-processing in a receiving device according to Embodiment 5 of the present invention;

[Fig. 14] explanatory drawing for generating repetitive bit trains according to Embodiment 6 of the present invention;

[Fig. 15] explanatory drawing of an interleaver and a deinterleaver according to Embodiment 7 of the present invention;

[Fig. 16] block diagram of the conventional UWB transmitting device; and

[Fig. 17] block diagram of the conventional UWB receiving device.

[Description of symbols]

[0160]

1	encoder
2, 60	serial-to-parallel converter
3, 30	pulse generator
3a, 3b, 3n	repetitive pulse generator
4, 50	parallel-to-serial converter
5, 90, 100	antenna
6, 120	pulse wave-shape correlator
7	pulse train integrator
8, 150	decoder
9	decision circuit
10	information signal source
20	encoder
31	first pulse train generator
32	second pulse train generator
33	n-th pulse train generator
40	transmitting control unit
70	bit train generator
80	interleaver
110	receiving unit
130	integrator
140	receiving control unit
160	decision unit
170	deinterleaver
301	input terminal
302	output terminal
303	transceiving control unit

304 antenna switching unit

[Document Name] ABSTRACT

[ABSTRACT]

[PROBLEM TO BE SOLVED] To provide a transmitting device and a receiving device for an ultra wideband communication system, the transmitting and receiving devices being able to perform high-quality data transmission without reducing transmission speed, by lifting the restriction over the number of pulses in the UWB-IR method and by posing weighting on the encoded bits.

[SOLUTION] A transmitting device according to the present invention includes an encoder 20, a pulse generator 30, a transmitting control unit 40, a parallel-to-serial converter 50, and an antenna 90. The pulse generator 30 includes a first pulse train generator 31, a second pulse train generator 32, ... and an n-th pulse train generator 33. A k-bit information bit train is inputted from an information signal source 10. The encoder 20 encodes the k-bit information bit train into an n-bit parallel encoded bit train at a coded rate of (k/n). The pulse generator 30 generates n-piece repetitive pulse trains, and the antenna 90 transmits the n-piece repetitive pulse trains as UWB-IR. A number of pulses of the n-piece repetitive pulse trains is adaptively changed.

[SELECTED FIGURE] Fig. 3